Cayuga Lake Watershed Preliminary Watershed Characterization

Executive Summary

September 2000

This report was prepared for the Town of Ledyard with funding provided by the New York State Department of State through the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.

This report was prepared by:
Genesee/Finger Lakes Regional Planning Council
1427 Monroe Avenue
Rochester, New York 14618
www.gflrpc.org
716-442-3770

Limnological Consultants:
EcoLogic
5891 Ridge Road
Cazenovia, New York 13035
315-687-6397

Acknowledgements

The Cayuga Lake Watershed Management Plan Project is greatly indebted to the many individuals and organizations who contributed their time, expertise, and resources during the development of this Preliminary Watershed Characterization. Their tireless efforts will greatly benefit future protection of the Cayuga Lake Watershed for year to come. The Cayuga Lake Watershed Management Plan Project would like to thank all of the members of the Intermunicipal Organization, Technical Committee, Agricultural Committee, and the Education & Public Participation Committee for sharing their wide array of experience and technical skills. There is great appreciation for the time and efforts of all of the private citizens as well. The following organizations shared their personnel, data, meeting locations, and many other resources:

Atlantic States Legal Foundation
Cayuga County Cornell Cooperative Extension
Cayuga County Department of Health
Cayuga County Planning Department
Cayuga County Soil & Water Conservation District
Cayuga County Water Quality Management Agency
Cayuga Lake Watershed Network
Cayuga Lake Watershed Management Plan Intermunicipal Organization
Cayuga Nature Center
Central New York Regional Planning & Development Board
Cornell University Center for the Environment
Cortland County Planning Department
Cortland County Soil & Water Conservation District
Cortland County Water Quality Coordinating Committee
EcoLogic
Empire State Development Corporation
Farm Bureau
Genesee/Finger Lakes Regional Planning Council
Ithaca-Tompkins County Convention and Visitors' Bureau
Montezuma National Wildlife Refuge
Schuyler County Cornell Cooperative Extension, Planning and Community Development Division
Schuyler County Soil & Water Conservation District
Schuyler County Watershed Protection Agency
Seneca County Board of Supervisors
Seneca County Building Enforcement Office
Seneca County Department of Health
Seneca County Planning Department
Seneca County Tourism Promotion Agency
Seneca County Soil & Water Conservation District
Seneca County Water Quality Committee
Southern Tier Central Regional Planning and Development Board
Southern Tier East Regional Planning and Development Board
Tioga County Department of Economic Development and Planning
Tioga County Department of Environmental Health
Tioga County Soil & Water Conservation District
Tompkins County Cornell Cooperative Extension
Tompkins County Municipal Officials' Association
Tompkins County Planning Department
Tompkins County Soil & Water Conservation District
Tompkins County Water Resources Council
Town of Ledyard
New York State Department of Environmental Conservation, Division of Fish, Wildlife & Marine Resources
New York State Department of Environmental Conservation, Division of Water
New York State Department of Environmental Conservation Region 7
New York State Department of Environmental Conservation Region 8
New York State Department of Environmental Conservation, Wildlife Resources Center - New York Natural Heritage Program
New York State Department of Health
New York State Department of State, Division of Coastal Resources
New York State Office of Real Property Services
United States Geological Survey
United States Department of Agriculture – Natural Resource Conservation Service
Wells College

Significant contributions to this report include the following:

Sharon Anderson, Tompkins County Cornell Cooperative Extension
Rich Ayers, Yates County S&WCD
Charles Bennett, Streambank Inventory Project
Kathy Bertuch, Central New York Regional Planning & Development Board
Clifford Callinan, NYSDEC, Division of Water
Justin Damann, Roadbank Inventory Project
Michelle Debwah, Genesee/Finger Lakes Regional Planning Council
Steven Eidt, NYSDEC Region 7
Brianne Ferry, Genesee/Finger Lakes Regional Planning Council
Jordan Gass, Streambank Inventory Project
Phil Griswold, Seneca County S&WCD

Kate Hackett, Tompkins County Planning Department
Jason Howard, Genesee/Finger Lakes Regional Planning Council
Sylvia Hurlbut, Town of Ledyard
Tom Jazikoff, Montezuma National Wildlife Refuge
Robert L. Johnson, Cornell University
William Kappel, USGS
Jose Lozano, City of Ithaca
Jim Malyj, Seneca County S&WCD
Kelly McCutcheon, Roadbank Inventory Project
Elizabeth Moran, EcoLogic
Pamela O'Malley, Central New York Regional Planning & Development Board
Tom Pearson, NYSDEC Region 8
James R. Peek, NYSDEC Region 8
Richard Perrin, Genesee/Finger Lakes Regional Planning Council
Tim Pezzolesi, Cayuga County Cornell Cooperative Extension
John Roebig, EcoLogic
Daniel Sawchuck, NYSDEC Region 7
Craig Schutt, Tompkins County S&WCD
Erin Smith, Seneca County S&WCD
Sean Vormwald, Streambank Inventory Project
Linda Wagenet, Cornell Center for the Environment
Nicole Weiss, Genesee/Finger Lakes Regional Planning Council
David Zorn, Genesee/Finger Lakes Regional Planning Council

Others who have contributed include the following:

John M. Andersson, Tompkins County Department of Health, Division of Environmental Health Services
Amanda Barber, Cortland County SWCD
Tom Bell, Cortland County SWCD
Jacquie Bow, Tompkins County Planning Department
Donald Bowen, Cayuga County Health and Human Services Department
Thomas L. Chiotti, Bureau of Fisheries, Division of Fish and Wildlife, NYSDEC
Jerry Coder, Education, Public Participation & Outreach Committee
Nicholas Colas, Cayuga County Planning Department
Daniel S. Dineen, Cortland County Department of Planning
Jim Eckler, Bureau of Wildlife, NYSDEC Region 8
John Ferranti, Atlantic States Legal Foundation
John Fessenden, Cayuga Lake Watershed Network
Dave Forness, NYSDEC Region 7
Tracy Gingrich, US Fish and Wildlife Surface, Montezuma National Wildlife Refuge
Deb Grantham, Education, Public Participation & Outreach Committee
Brian Hall, Cortland County S&WCD
Jim Hanson, Tompkins County Planning Department
Janet Hawkes, Cayuga Nature Center
John Helgren, Cortland County Health Department, Division of Environmental Health
Gene Holcutt, Cayuga Lake Watershed Network
Tee-Ann Hunter, Education, Public Participation & Outreach Committee
Art Jacobson, Bureau of Wildlife, NYSDEC – Wildlife Resources Center
Clark Jillson, Cayuga County S&WCD
Betsy Landre, Finger Lakes Association
Michael Medovich, Southern Tier East Regional Planning & Development Board
Jim Skaley, Education, Public Participation & Outreach Committee
Linda Szeliga, USDA-NRCS
Jane C. Thapa, P.E, NYS Department of Health/BPWSP
Dan Winch, Tompkins County WRC
Cal Wysokowski, Tompkins County Area Development
Sara Young, Cayuga County Planning Department

Table of Contents

I.	**Purpose, Objective and Focus**	**1**
II.	**Findings and Conclusions**	**1**
III.	**The Nature of the Basin** *The Watershed* *Climate* *Topography* *Bedrock Geology* *Surficial Geology* *Soils* *Surface Water Resources* *Groundwater Resources* *Terrestrial Vegetation* *Wildlife* *Land Use/Land Cover* *Population*	**4**
IV.	**The Nature of Cayuga Lake** *Lake Morphometry* *Thermal Stratification and Mixing* *Water Chemistry* *Trophic Status* *Pesticides and Other Organic Compounds* *Sediment Quality* *Biological Community* *Nuisance Organisms*	**9**
V.	**Human Uses of the Lake and Watershed** *Surface Runoff* *Roadbank & Streambank Erosion* *Underground and Above Ground Storage Tanks* *Hazardous Materials* *Hazardous Spills* *Industrial Sources* *Commercial Sources* *MunicipalSources* *Agricultural Sources* *Tourism and Recreation*	**14**
VI.	**Regulatory/Programmatic Environment** *Federal* *State* *County* *Municipal* *Other*	**18**
VII.	**Findings of Desired State (Public Participation Efforts)**	**23**
VIII.	**Next Steps**	**23**
	References	24
	Glossary of Acronyms	A-1

I. PURPOSE, OBJECTIVE AND FOCUS

The Cayuga Lake Preliminary Watershed Characterization Report is a working document developed to meet two objectives:

(1) Present the current state of scientific understanding of Cayuga Lake and its watershed with a focus on water quality of the lake and its tributaries. Physical, chemical, and biological conditions are discussed. Specific areas of potential concern and areas where more data are needed are highlighted

(2) Describe the multitude of activities underway by government, the private sector, and individuals to protect and improve this unique resource.

The overall goal is to provide a basis for understanding the state of the watershed.

This report is the first phase of the Cayuga Lake Watershed Management Plan. The process to develop a Management Plan for the lake began in 1998 when grant funds from New York Department of State, Division of Coastal Resources, Waterfront Revitalization Program were awarded to the Town of Ledyard and matched by local contributions and in-kind services. Additional funding was provided by the Empire State Development Corporation. Two multi-county planning agencies (Central New York Regional Planning and Development Board and Genesee/Finger Lakes Regional Planning Council) are providing administrative, technical, and in-kind support. The watershed management planning process requires several overlapping and interrelated phases: fact finding, public participation, and education.

An intermunicipal organization (IO) has been formed to foster participation by the many municipalities in the watershed and ensure that the plan reflects local priorities. IO membership is comprised of watershed municipalities (counties, cities, towns and villages). Approximately 66% of watershed municipalities have participated in IO activities to date. Twenty-nine of the 50 have signed a cooperative agreement. Non-municipal stakeholders participate via avenues such as membership on IO committees, the Cayuga Lake Watershed Network, and public information forums occurring throughout the project.

This report draws on many sources of data and information. Statistics have been compiled for the description of the watershed and potential sources of contamination. Historical data on Cayuga Lake and its tributaries date back to the early 1900s. Researchers at area universities have examined aspects of the lake and watershed. State agencies, notably the New York State Department of Environmental Conservation (NYSDEC) and the New York State Department of Health (NYSDOH), conduct monitoring programs to characterize water quality and the fish community and identify any impairment to designated uses. Additionally, the NYSDEC publishes the Priority Waterbodies List for each basin on a rotating basis in an attempt at characterizing the surface water bodies within that basin. The Cayuga Lake Watershed surface waters are dealt with in the 1996 Priority Waterbodies List for the Oswego-Seneca-Oneida River Basin. Two federal agencies, United States Geologic Survey (USGS) and the United States Environmental Protection Agency (USEPA), have included Cayuga Lake in research programs. Some long-term monitoring has been done by agencies such as the Soil and Water Conservation Districts (SWCD). Users of the resource, for public drinking water supply, wastewater disposal, or noncontact cooling water, monitor to meet permit requirements.

Draft sections of this report were reviewed by the Technical Committee of the IO, which includes representatives of the following: each County Water Quality Coordinating Committee (WQCC), New York State Department of State (NYSDOS), NYSDEC, Division of Water and Regional Water Engineers, Montezuma Wildlife Refuge, Cayuga Lake Watershed Network (CLWN), USGS, United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), Wells College, Cornell University Center for the Environment, and the Atlantic States Legal Foundation. The main functions of the Technical Committee include data and information identification, technical education and public participation review, interim recommendation criteria and project review, and Preliminary Watershed Characterization input and review.

II. FINDINGS AND CONCLUSIONS

Cayuga Lake has a rich history of research activities. Physical, chemical, and biological conditions of the lake and its tributary streams have been investigated for decades. The lake and its watershed remain the focus of several long-term monitoring initiatives. However, several important data gaps remain.

Cayuga Lake's water quality is generally very good. The lake is a valued and visible resource, serving as a public water supply and focal point for recreation. The fish community is diverse and productive. Overall, the tributary streams exhibit moderate to high water quality and habitat conditions that support a balanced biological community.

Despite the general conclusion that water quality of the lake and its tributary streams is high, a number of specific areas of concern are evident. These are summarized below, along with a discussion of additional data needed to identify specific priority areas and define effective remedial strategies.

- ***Fertilizers and pesticides*** have been detected in both tributary streams and the lake. Recent data provide direct evidence of chemical loss from the landscape and transport to the lake. Almost half of the land in the watershed is in active agriculture, and this land use contributes nitrate-nitrogen and pesticides (most notably, herbicides used in corn cultivation) to the lake. Using analytical methods with low detection limits, scientists from USGS and NYSDEC have documented trace concentrations of pesticides in the streams and lake. The chemicals are present at levels far below ambient water quality standards or guidelines based on toxicology and risk assessment. No exceedances of standards or guidelines developed to protect human health and the environment have been detected.

Data Needs: Pesticides and Nitrates

Long-term effects of exposure to trace concentrations of many of these chemicals are unknown. It is important to continue to track these chemicals in all components of the ecosystem: water column, sediments, and throughout the food web.

Additional monitoring of pesticides in streams draining mixed land uses (agricultural and residential) is needed to further our understanding of the sources, fate, and significance of these chemicals. Stream monitoring must be designed to reflect the hydrologic cycle, the agricultural cycle, and the mix of land use and geology in the subwatersheds.

The potential for agricultural chemicals to be adsorbed to sediment particles and transported to the lake has not been fully assessed. Limited testing of lake sediments has not detected agricultural residues. However, testing has not been conducted in depositional areas of streams draining agricultural watersheds, nor in the lake at the mouths of tributaries.

Groundwater concentrations of pesticides and nitrates are not well documented. Since much of the watershed relies on groundwater, this data gap is significant.

- ***Sediment*** is a significant water quality, habitat, and use impairment issue, particularly in the southern tributaries and southern Cayuga Lake. Destruction and fill of the extensive wetland areas in southern Cayuga Lake in the early 1900s has exacerbated this problem by removing a natural filtration process that captured sediment before it flowed into the lake. In the southern tributaries, the primary source of sediment appears to be streambank erosion, not runoff from construction sites or cultivated fields. The primary sources of sediment in other tributaries are not known and may differ based on land use and geology.

Data Needs: Sediment

Before and after monitoring is lacking on tributaries where remedial measures such as streambank stabilization or stormwater controls has been implemented. Monitoring should occur over a range of hydrologic conditions, particularly high flow events.

- ***Heavy metals*** are present in at elevated concentrations in sediments of Fall Creek and nearshore areas of southern Cayuga Lake. Heavy metals may enter the aquatic system from industrial discharges, stormwater runoff, or atmospheric deposition.

Data Needs: Heavy Metals and Stormwater Quality

The quality of urban stormwater has not been assessed in the Cayuga Lake watershed. The concentration of heavy metals, phosphorus, sediment, petroleum compounds, and pathogens in stormwater is not characterized; moreover, the significance of this source in relation to other sources is not known.

There are no recent data characterizing chemical quality of precipitation (wetfall and dry fall) in the basin. This is important for load calculations as well as for general surveillance of acid precipitation.

Additional sampling of tributary sediment in subwatersheds and stream reaches with different mixes of land use might help identify factors contributing to the presence and concentration of heavy metals.

- ***Phosphorus*** is the limiting nutrient for algal growth in Cayuga Lake as it is for most inland lakes in the Northeast. Recent monitoring data confirm that Cayuga Lake is mesotrophic, with moderate levels of primary productivity. However, the shallow areas at the northern and

- southern ends of the lake exhibit higher levels of phosphorus and productivity. Both of these segments are listed by New York State as priority areas, indicating water quality concerns. Phosphorus sources include the two wastewater treatment plants discharging to the southern lake basin and runoff from residential and agricultural areas. Septic systems are considered by NYSDEC to be significant sources of phosphorus to the northern segment.

Data Needs: Phosphorus

Annual monitoring of a limited suite of limnological parameters will provide a basis for long-term trend analysis. These parameters include total phosphorus, soluble reactive phosphorus, total soluble phosphorus, dissolved oxygen profiles, chlorophyll a, Secchi disk transparency, and turbidity.

Biological parameters can provide information regarding trends as well. Species composition and abundance of the macroinvertebrate community (aquatic insects and worms found in the stream bed) of the tributary streams can be used to indicate water quality conditions and assess site-specific impacts of point and nonpoint discharges. Sampling tributaries in various geologic and land use settings can identify areas where the biological community is stressed.

A mathematical model would provide a tool for linking the inputs from the tributaries to the lake's water quality response.

- ***Exotic species***. Because of its connections to the Great Lakes through the Seneca River, Cayuga Lake is vulnerable to invasion by nonindigenous species of plants and animals. There have been a number of exotic species invading Cayuga Lake over the years. Three recent invaders are a focus of special concern due to their potential to alter the food web. These organisms are the zebra and quagga mussel (*Dreissena polymorpha* and *Dreissena bugensis*) and a predatory cladoceran zooplankton (*Cercopagis pengoi).* The macrophyte Eurasian water milfoil (*Myriophyllum spicatum*) is another introduced species that has, until recently, been a nuisance in Cayuga Lake.

Data Needs: Exotic Organisms

The impacts of exotic organisms on the food web and ecology of Cayuga Lake will be an important area of research. The macrophyte data illustrate the need for long-term monitoring to differentiate trends from year-to-year variability.

- ***Pathogens and indicators.*** The presence of pathogenic microorganisms in the lake and its tributary streams is a potential area of concern. Pathogens originate from untreated or inadequately treated human sewage and wild and domestic animal waste. Human exposure to pathogens can occur from direct contact with or ingestion of contaminated waters. The potential presence and abundance of pathogenic microorganisms is assayed using indicator organisms such as coliform bacteria.

Data Needs: Pathogens and Indicators

Measurements of pathogens and indicator organisms in Cayuga Lake are very limited. Storm event monitoring in the lake and streams could help define the importance of urban runoff as a source of pathogens. The importance of waterfowl as a source of microorganisms is not known.

Based on generalized geology and soils maps, there are large areas of the watershed with severe constraints to on-site wastewater disposal systems (septic systems). There has been no watershed-wide effort to characterize the performance of these individual systems and how leachate from septic systems contributes to nitrate, phosphorus, and pathogen levels. The experience of Cayuga County, which has a comprehensive inspection program, could serve as a guide.

- Impacts of non-permitted, pre-permitted or unenforced uses

Data Needs: Sources

Additional field work could provide useful information on pre-permit and unpermitted underground storage tank sites, waste sites, junk yards and dumps, mines and wells. There is a need for better and more accurate recreational data including the impact of boating and fishing on water quality.

- *Floodplain delineation, management and mitigation..* Water level management and flooding are important issues. The loss of wetlands and increase in impervious areas have altered the natural hydrology.

- Impacts of Cornell *Lake Source Cooling*

- *Native American territory* disputes

III. THE NATURE OF THE BASIN

The Watershed

The Cayuga Lake watershed is part of the 5,100 square mile Seneca-Oneida-Oswego River watershed that drains to Lake Ontario (see Figure 1). The entire drainage basin of Cayuga Lake includes the basins of Seneca and Keuka Lakes. Outflow from these lakes enters Cayuga Lake at the extreme northern end via the Seneca-Cayuga Canal. However, because both Keuka and Seneca Lake Watersheds are undergoing a watershed management planning process with associated reports similar to this one, the Cayuga Lake Preliminary Watershed Characterization will concentrate on just the watershed that directly drains to Cayuga Lake.

The Cayuga Lake Watershed covers 785 square miles (United States Department of Interior, 1971). There are 44 municipalities and six counties that are all or partially in the watershed (see Map 2.1.1a and Figure 2). The watershed is home to over 120,000 people. For the purposes of this study the watershed has been broken down into 46 subwatersheds based on the major tributaries of Cayuga Lake (see Map 2.1.1a). The center of Cayuga Lake is located at latitude 42^{o} 41' 30" N and longitude 76^{o} 41' 20" W. Its average water-surface elevation is 382 feet above sea level.

Many factors enter into the use, type of pollutants, source of pollutants, and overall water quantity and quality in the Cayuga Lake Watershed. These include natural factors such as climate, topography, geology, soils, water resources, vegetation and wildlife. And they include human factors such as land use, demographics, economic development, tourism and recreation. The state and sustainability of the watershed depends on the interrelationship between the natural and human factors.

Climate

The general climatic conditions of the watershed can be described as humid continental with warm

Figure 2 Municipalities in the Cayuga Lake Watershed

Tompkins County
- Town of Caroline
- Town of Danby
- Town of Newfield
- Town of Dryden
- Town of Ithaca
- Town of Enfield
- Town of Lansing
- Town of Ulysses
- Town of Groton
- City of Ithaca
- Village of Dryden
- Village of Trumansburg
- Village of Lansing
- Village of Cayuga Heights
- Village of Freeville

Schuyler County
- Town of Hector
- Town of Catharine*

Cortland County
- Town of Harford
- Town of Virgil
- Town of Cortlandville
- Town of Scott*
- Town of Homer

*Municipalities with small portion in watershed

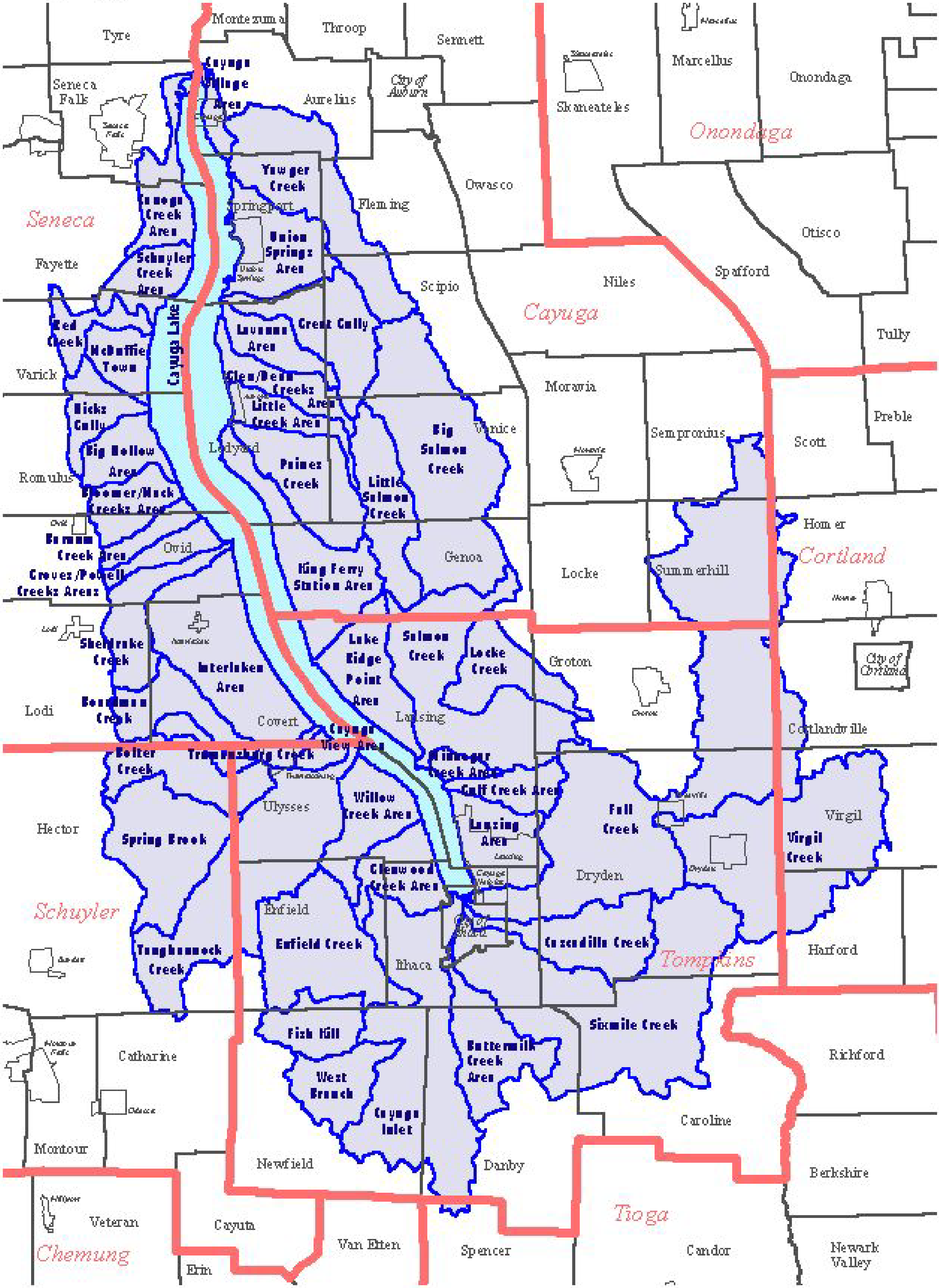
Cayuga County
- Town of Summerhill
- Town of Genoa
- Town of Sempronius
- Town of Locke*
- Town of Venice
- Town of Ledyard
- Town of Scipio
- Town of Fleming
- Town of Aurelius
- Town of Springport
- Village of Aurora
- Village of Union Springs
- Village of Cayuga

Tioga County
- Town of Spencer

Seneca County
- Town of Covert
- Town of Lodi
- Town of Ovid
- Town of Romulus
- Town of Fayette
- Town of Varick
- Town of Seneca Falls
- Village of Interlaken

summers and long, cold winters. The area lies on or near the major west to east track of cyclonic storms and hence is characterized by variety and frequent periods of stormy weather, particularly in the winter. Average daily air temperatures of 90^{o} F or higher are rare. Average daily winter temperatures of 0^{o} F or

Cayuga Lake Watershed and Subwatersheds



This map was prepared for the New York State Department of State with funding from the Environmental Protection Act. Additional funding was provided through the Empire State Development Corporation.

Source: Genesee/Finger Lakes Regional Planning Council, 1998.

Base Map: New York State Department of Transportation, February 1996.

1:369633

0 5 10 Miles

Prepared by Genesee/Finger Lakes Regional Planning Council, 19 less occur fewer than 15 times per year. The freeze-free season averages approximately 150 days. Annual precipitation ranges from approximately 25 inches to 45 inches per year with the average yearly precipitation approximately 35 inches per year. Generally the summer months are the highest average daily precipitation rates (Northeast Regional Climate Center).

One of the more persistent climatic features of the Cayuga Lake area is cloudiness, especially during the winter months. Ithaca averages about 175 cloudy days a year. The percentage of possible sunshine at Ithaca is less than 30% in November and December and increases to a maximum of 60% in June and July. Prevailing winds in the area are from the southwest during the summer and the northwest in the winter. Velocities in Ithaca average 7-10 mph from May through October and 11-12 mph during the colder months.

Topography

The Cayuga Lake Watershed is located in a glaciated valley with flat terrain and low relief characteristics in the northern portion and higher elevations with more hilly terrain with greater relief beginning near the northern third of the watershed and extending down to the southern end. The more dramatic increases in elevation and steeper slopes that define the gorges of the watershed begin on the eastern side near the towns of Springport and Scipio, while on the western side the same topographic effect begins further south near the Town of Ovid.

In the northern third of the watershed, elevations range from approximately 394 feet to 1050 feet above sea level. Elevations in the southern end of the watershed reach approximately 1804 feet above sea level. The higher elevations of Cayuga Lakes' southern tributaries combined with the "hanging valleys" produced by glaciation, have created steep gorges and scenic waterfalls.

The topography of the watershed was formed through uplift and erosion of the land surface that began approximately 200 million years ago with the draining of the inland sea which covered all of what is now New York. Periods of glacial advance and recession further modified the land surface by deepening and widening the Cayuga Lake Valley, and smoothing the surrounding hills. Recent erosion has further modified post-glacial stream channels and softened the land-surface topography left by the receding glaciers.

Bedrock Geology

Approximately 400 million years ago unconsolidated sediments were deposited in the Finger Lakes when the Western Oswego River Basin was still an inland sea. These unconsolidated sediments laid down in shallow inland seas, included clay, silt, sand, and calcium carbonate deposits, which were compressed into bedrock by the weight of overlying sediments. Later, periodic arid conditions dried up the inland waters, resulting in precipitation of mineral salts (gypsum and halite [rock salt]) within the unconsolidated clay and silt deposits. These deposits were later mined.

While the bedrock formations in the watershed are not of uniform composition, the formations can be separated into three general classes: (1) shale, siltstone, and sandstone, (2) carbonate rock, and (3) gypsum and salt-bearing shale. The shale, siltstone, and sandstone formations comprise the majority of bedrock formations in the watershed, present from the southern sections of the Towns of Fayette and Springport to the southern boundary of the watershed.

The carbonate rock and gypsum and salt-bearing shale classes are present in the northern end of the watershed. The carbonate rock class can be found in the northern half of the towns of Fayette and Springport and in the southern half of the towns of Aurelius and Seneca Falls as well as the Village of Seneca Falls. Carbonate rock, mostly limestone, are highly susceptible to groundwater contamination due to solution channels and sinkholes which can introduce surface contaminants.

Surficial Geology

The majority of the Cayuga Lake Watershed consists of glacial till of variable texture and thickness, most notably in the middle of the watershed east and west of the lake. The texture of the till varies but is predominantly poorly sorted, sand-rich silt and clay. Along the east and west borders of the lake from the Towns of Ledyard (east) and Fayette (west) to the Ithaca area, bedrock is either exposed or within several feet of the land surface.

On the east side of the lake, north of the Town of Summerhill is lacustrine (material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised) sand, and well-sorted, permeable quartz sand. To the south of Summerhill, and throughout the southern third of the watershed, areas of mixed clay, silt, sand and gravel (kame deposits) of variable texture and thickness are found. Kame deposits are also located throughout the southwestern portion of the watershed.

The most northern portion of the watershed is primarily lacustrine silt and clay, which has a low permeability and is up to 150 feet thick. At the very northern boundary of the watershed in the Montezuma Wildlife Refuge are wetland deposits that overlie calcium rich clays (marl) and lacustrine silt.

Soils

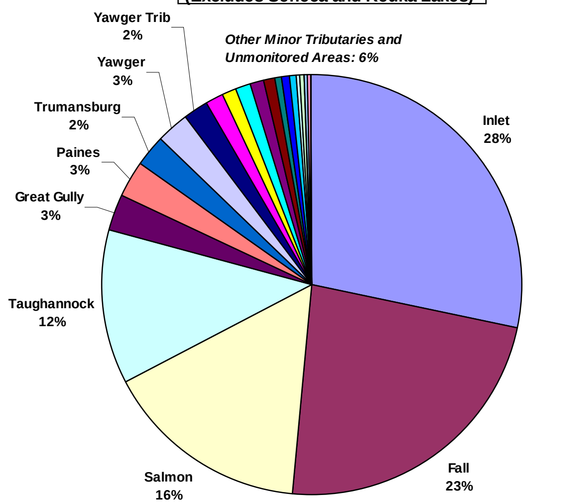
Soil is the product of the interaction among five major soil-forming factors: parent material, topography, plant and animal life, climate, and time (USDA, Soil Conservation Service). Most soils in the watershed formed after the last glacier receded from the area about 14,000 years ago. All soils have not reached the same stage of development, however, because various soil-forming/modifying factors influence the rate and depth of development.

The shape of the land surface, the slope, and the depth to the water table influence the formation of soils in the watershed. Since the area has a humid, temperate climate, these conditions tend to promote the development of moderately weathered, leached soils. The native forests, consisting of northern hardwoods and pine, influenced early soil formation. Humans have further modified the soils through clearing of forests, cultivation (mixing soil horizons through plowing), the addition of nutrients through fertilizers, and accelerated soil-erosion processes by removing vegetation and the root mat which would normally 'hold' soils in place. In geologic terms though, the soils in the watershed are relatively young.

Surface water resources

The dominant surface water feature of the basin is the lake itself. A network of more than 140 streams flows into the lake. Because of the topography of the watershed, many of these streams are small and intermittent. There are a few major streams that drain larger subwatershed areas and these are all found in the southern part of the watershed (Figure 3). The largest streams are Cayuga Inlet (which includes Six Mile, Cascadilla, Enfield and Buttermilk Creeks) and Fall Creek. Together, these two large streams drain just over half of the direct drainage (excluding the contribution from Seneca and Keuka Lakes), and contribute approximately 40% of the flow into the lake. Fall Creek and the Inlet flow into the southern end of Cayuga Lake. Salmon Creek (on the east side of the lake) is the next largest subwatershed. The watershed area of this stream is approximately 16% of the direct drainage area. Taughannock Creek (on the west side of the lake) is the next largest subwatershed representing approximately 9% of the direct drainage area.

Figure 3
Drainage Areas of Subwatersheds
(Excludes Seneca and Keuka Lakes)



Groundwater resources

Groundwater is precipitation that collects within the pores of soils or crevices and fractures in bedrock and can be used as a water supply. Many residents and businesses within the watershed access groundwater supplies through wells. According to USGS (Miller) the aquifers in the Cayuga Lake watershed with the greatest potential yield are located in the Cayuga Inlet, Fall Creek, and upper Salmon Creek Valleys. These are sand and gravel aquifers overlain by less permeable materials - silt, clay, or glacial till. Wells in these aquifers have the potential to yield from 5, to greater than 500 gallons per minute.

Groundwater quality depends on the composition of the soils and rocks. Because the watershed encompasses more than one geologic region, groundwater quality is variable. The northern region of limestone geology has well-buffered alkaline groundwater of relatively high quality and yield. Proceeding southward, groundwater quality reflects the sandstone and shale geology with higher concentrations of dissolved mineral salts and sulfur.

According to a report published by the USGS in 1975, calcium and sulfate concentrations were highest in the northern portion of the Cayuga Lake

Watershed. In the southern portion of the watershed, high chloride concentrations were detected in deeper wells. In the northern regions elevated chlorides in groundwater are a localized problem in the Seneca River and Barge Canal area near Mudlock.

Terrestrial vegetation

The Cayuga Lake watershed is located within the regional forest formation designated by the U.S. Forest Service as the Allegheny Section of the Northern Appalachian Highland Division which consist of Hemlock-White Pine, and Northern Hardwoods. The Allegheny Section is a broad forest type beginning at the northern edge of the Finger Lakes and continuing south, and covering most of the northern half of Pennsylvania.

The lower elevation segments of the Cayuga Lake Watershed, (in the northern part of the watershed), are part of the Lake Ontario lake-forest plain (dominant species include oak, hickory, and tulip poplar). In contrast, the higher elevation areas (which tend to be in the southern part of the watershed) are considered part of the more southern assemblage (sugar maple, beech, yellow birch, hemlock, and white pine). As a result of local variation in climate, the watershed contains species common to both forest types. Therefore, stand composition varies greatly with site, climate, and land-use history.

Wildlife

Based on the division of New York State into ecozones (zones that group living organisms that behave as a unit), nearly the entire watershed is within the Erie-Ontario Plain. Ecozones are determined by major physiographic (physical geographic) differences and are used to define and manage wildlife habitat on a broad scale.

The watershed contains a number of diverse habitats that support a wide array of wildlife. Forests and wetlands throughout the watershed, as well as agricultural lands and transitional areas, provide dwelling and feeding areas for various species of mammals, birds, reptiles and amphibians. The Montezuma National Wildlife Refuge, predominantly north of the watershed, provides habitats for a number of species. The refuge's primary purpose is to provide habitats for waterfowl, migratory birds, and endangered species. Nearly 75% of the refuge is classified as wetland, adding to the diversity of wildlife already present in the watershed. According to the NYSDEC's Natural Heritage Program (NYSDEC, 1999), there are two species of protected birds present in the watershed based on existing occurrences. They are the great blue herron and the short-eared owl. Game species present in the watershed include deer, coyote, opossum, rabbit, squirrel, hare, raccoon, red and gray fox, grouse, pheasant, woodcock, ducks, and geese.

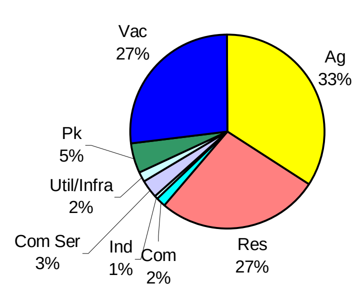
Land use/Land cover

Based on New York State Office of Real Property Services (NYSORPS) data (Figure 4), the single largest land use in the Cayuga Lake watershed is agriculture related (34 %), followed by residential (27 %), vacant (27 %), park lands (5 %), community service (3.2 %), commercial (1.6%), utility and infrastructure (1.6%), and industrial (0.6 %). However, 55% of the vacant land is classified as agricultural vacant.

Of the agricultural land in the watershed the largest portion (56.8%) is land usage related to livestock, followed by field crops (42.5%), vineyard (0.5%), orchard (0.1%), and nursery and greenhouses (0.1%). The highest percentage of residential land use by residential acreage in the watershed is low density residential (81%), followed by high density residential (9%), mobile homes and parks (9%), and low density seasonal residential (1%). Educational facilities account for over 79% of community service land use and over 2% of the overall land use in the watershed, largely due to the presence of Cornell University and Ithaca College.

The majority of the land cover in the watershed is classified as herbaceous planted/cultivated, which is vegetation that is planted, tilled, or subject to other intensive management or manipulation. This is largely due to agriculture (pasture, hay or row crops) but it includes lawns, parks and golf courses as well. The herbaceous planted/cultivated land cover is widely dispersed throughout the watershed, except for the southern end. Here the majority of the land

Figure 4
Cayuga Lake Watershed Land Use By Acreage



cover is categorized as natural forested upland or wetland where vegetation is dominated by trees generally forming greater than 25 percent canopy cover, or vegetation where the substrate (floor) is periodically saturated or covered with water (USGS, 1998).

Population

Portions of six counties and 44 municipalities lie within the Cayuga Lake Watershed. Between 1970 and 1990, the population of these municipalities grew 16.5%, with 8.9% of the increase taking place in the first decade. Only the Seneca County municipalities lost population (-8.1%) between 1970 and 1990. The Town of Spencer grew the fastest (50%). Tompkins County municipalities grew at a rate of 22% between 1970 and 1990. Each of the remaining counties' municipalities within the watershed grew between 11% and 16 % (USDC). As a whole, the population of the municipalities within the watershed is expected to increase by approximately 10,000 persons or 7% by 2010 (New York State Association of Regional Councils).

The Cayuga Lake watershed is predominantly rural in character. The combined population density for all of the municipalities in the watershed in 1990 was approximately 104 persons per square mile of land area. The greatest population density is at the southern end of the watershed in Tompkins County where Ithaca, the only city in the watershed, is located. Population density in Ithaca is 5,371.1 persons per square mile of land area. In contrast, the average population density for municipalities in Cayuga, Cortland, Schuyler, and Seneca counties is 62.1 persons per square mile of land area. When the City of Ithaca is excluded, the population density for the watershed is 82.9 persons per square mile of land area.

IV. THE NATURE OF CAYUGA LAKE

Lake Morphometry

Cayuga Lake is the second largest of New York's Finger Lakes based on water volume and surface area. It is situated in a glacially carved valley at the northern edge of the Appalachian Uplands physiographic region of New York State. Average water surface elevation is 382 feet above mean sea level and maximum depth is 435 feet. The lake bottom extends well below sea level. The great depth of Cayuga Lake, second only to Seneca among the Finger Lakes, is attributed to rock scour from glaciation. The Cayuga Lake basin appears to have originated as a preglacial stream valley that was overdeepened by glacial erosion. Based on seismic surveys, bedrock may lie as much as 794 feet below sea level, and the rock basin has been infilled by as much as 741 feet of glacial and postglacial sediment.

Cayuga Lake is long and narrow, extending approximately 38 miles from Ithaca to the Seneca River outlet at Mudlock. Mean width is 1.75 miles. At its widest point, Cayuga Lake is 3.5 miles across. Volume is estimated at 331,080 million cubic feet at a lake elevation of 380.5 feet. Surface area is 66.4 sq. miles. The lake is relatively shallow at its northern end, deepens towards the south and has a relatively small, shallow shelf at its southern end. The deepest part of Cayuga Lake is a trough extending north from Myers Point to Long Point.

Thermal Stratification and Mixing

Cayuga Lake is a warm monomictic lake, meaning that there is one period of thermal stratification and one period of complete mixing each year. Considering winter as the beginning of the annual cycle, Cayuga Lake waters are cold and relatively uniform in temperature. Winds mix the lake waters from top to bottom, north to south.

As the sun's energy increases in spring, the lake gains heat and the upper waters begin to warm. Heating causes the water to expand and warmer, less dense water floats on top of the cooler water. More work is needed for winds to overcome density stratification and mix warmer water throughout the water column.

By June, Cayuga Lake waters stratify into three distinct layers: warm upper waters (epilimnion), cool lower waters (hypolimnion) and a middle transition layer (metalimnion). Density differences between the three layers are strong enough to prevent the winds from completely mixing the lake. During the summer, the lower waters remain isolated from the atmosphere.

By August, Cayuga Lake ceases to gain heat and the waters begin to cool. Heat loss continues through the fall. Eventually, the temperature of the upper water cools to the temperature of the lower waters, and thermal stratification breaks down. By early December of a typical year, the lake waters are again completely mixed.

The temperature difference between the surface and the deepest waters of Cayuga Lake can be 20 °C (36 °F) during the summer. Large-scale processes of

surface heat exchange and wind–induced mixing create these vertical temperature differences. Much less dramatic are differences in the horizontal dimension. Simultaneous measurements at different locations (same depth) reveal maximum temperature gradients in the range of 3°C (5.4°F).
These horizontal gradients are attributed to two mechanisms: localized input of heat and uneven heat distribution processes. Localized heat inputs can result from tributary inflows, effluent discharges, return of noncontact cooling water or microclimatic differences over the large lake. Uneven heat distribution can result from differences in wind energy across the lake surface or the effects of internal waves. Spatial temperature differences are most evident in spring and fall and diminish with increasing water depth.

Water chemistry

Cayuga Lake waters are moderately hard and well buffered, consistent with the predominance of calcareous parent material and soil in the watershed. Bicarbonate alkalinity is approximately 100 – 110 mg/l as $CaCO_3$. Major anions include chloride and bicarbonate, with relatively low amounts of sulfate; major cations include calcium and sodium, with relatively low concentrations of potassium and magnesium. Specific conductance, which is an indicator of total dissolved mineral salts, is consistently in the range of 380 – 480 μmhos/cm in the lake's open waters, away from the influence of tributary and wastewater inflows.

Chloride concentrations in surface waters reflect underlying geology, proximity to oceans, extent of road salting practices in the watershed, and any industrial or municipal discharge. Chloride concentrations in Seneca and Cayuga Lakes are elevated compared with the other Finger Lakes, and also compared with chloride concentrations in tributaries to these lakes. It appears that a small volume of groundwater with elevated concentration of sodium chloride may flow into Cayuga Lake.

Measurements of pH vary both diurnally (daily) and seasonally, but are consistently in the alkaline range. The highest pH values (in the range of 8.5 – 8.85) are measured in the upper waters during summer periods of algal activity as CO_2 is incorporated into biomass during photosynthesis. In the lower waters, where organic material is decomposed and CO_2 released, values between 7.2 and 7.9 have been reported.

Trophic Status

Phosphorus (P) is naturally present in all waters and is an essential nutrient for life. In most northeastern lakes, including Cayuga Lake, phosphorus is the limiting nutrient for algal growth. Because it is the limiting nutrient, the concentration of phosphorus in lake water is correlated with the abundance of algae. Given favorable light and temperature conditions, algal growth continues until the supply of phosphorus is depleted. The supply of phosphorus to Cayuga Lake depends on natural processes and human activities within the watershed.

Scientists and lake managers classify lakes according to their level of productivity (abundance of algae, plants, and other aquatic life forms and fish production) on a scale of trophic state. Oligotrophic lakes are nutrient-poor and low in productivity. Eutrophic lakes are well supplied with nutrients and support an abundance of algae and plants. Excessive algae will make a lake appear turbid or green, and diminish its attractiveness for recreational use. Decay of algae and aquatic plants reduces the concentration of dissolved oxygen in a lake's lower waters. Mesotrophic lakes are intermediate in nutrient supply and algal abundance.

Trophic state is assessed by several water quality measurements: phosphorus concentration, chlorophyll *a* (a plant pigment), dissolved oxygen concentrations through the water column, and water clarity (as measured by Secchi disk transparency or turbidity). Water quality monitoring programs of Cayuga Lake have included these parameters for decades. Ongoing programs continue to collect these data. Results of the monitoring indicate that Cayuga Lake is mesotrophic, exhibiting moderate levels of productivity.

However, the shallow southern and northern basins of the lake exhibit phosphorus concentrations and decreased water clarity conditions indicative of approaching eutrophic conditions. Plant and algal growth are more abundant. These shallow regions are affected by wastewater treatment plants, tributary streams, and waterfowl.

Dissolved oxygen (DO) concentrations are a significant factor affecting distribution, species composition, and abundance of the biological community. Variations in Cayuga Lake's DO concentrations occur seasonally and with depth. During the stratified period the lower waters remain isolated from atmospheric exchange and DO used up by aerobic organisms to decompose organic material is not replenished. The rate of DO depletion is an important indicator of trophic status. As algal biomass increases the rate of DO depletion increases and DO concentrations can decline in the lower waters. If DO falls below critical levels for aquatic life (4 – 5 mg/l) the habitat for cold water fishes such as salmonids is lost.

Cayuga Lake remains well-oxygenated throughout the stratified period. Dissolved oxygen levels remain above critical levels even in the deepest waters throughout the year. There have been no major changes in the DO levels since the earliest measurements obtained in 1910. This important finding is based on intensive investigations of the lake's water quality conducted by NYSDEC, USGS, and researchers from Cornell University. In contrast with other mesotrophic lakes, regeneration of P from bottom sediments is not an additional (internal) source of P. The well oxygenated hypolimnion and iron-rich sediments prevent diffusive flux (recycling) of soluble reactive phosphorus (SRP) to the hypolimnion from the bottom sediments.

Pesticides and Other Organic Compounds

Public suppliers of lake water are required by the NYSDOH to monitor for a comprehensive list of organic compounds. No organic contaminants have been detected in Cayuga Lake at concentrations exceeding water quality standards for human health.
The Bolton Point water supply (managed by the Southern Cayuga Lake Intermunicipal Water Authority) is included in a statewide survey for pesticides in water. In July 1997, Cayuga Lake water was tested for the presence of 47 pesticides using analytical techniques with very low limits of detection. Seven pesticides were detected in the sample collected at Bolton Point. Most of the analytes present are herbicides used on cornfields. Concentrations detected were well below any state or federal standard or guidance value developed to protect human health and the environment.

In 1998, research scientists from USGS and NYSDEC measured herbicides and breakdown products (metabolites) in storm flow samples of three tributaries to Cayuga Lake. The scientists sampled Cayuga Lake on two occasions after the storm. Results indicated that concentrations of herbicides were generally uniform throughout the north-south axis of the lake. In the summer, herbicide concentrations tended to be slightly higher in the upper waters. This pattern is a consequence of the timing of pesticide application with respect to the lake's thermal structure. Herbicides are typically applied after thermal stratification has developed in late spring. Streamflows transporting herbicides mix into the lake's warmer upper waters. Higher concentrations of chemicals were detected near mouths of tributaries draining agricultural areas.

Sedimentation Rate and Sediment Quality

The rate of sediment deposition in Cayuga Lake varies from south to north. Higher rates in the southern basin reflect the large hydrologic input from tributaries and the mixture of land use in the subwatersheds. The estimated sedimentation rate ranges from 0.2 – 1.6 cm/yr. (Yaeger 1999).

Only limited testing of the chemical quality of Cayuga Lake sediments has been conducted. Sediment testing is conducted throughout the Finger Lakes as part of the NYSDEC monitoring program; results will be released in early 2001. Recent testing of nearshore sediments in the southeastern region of Cayuga Lake detected concentrations of certain metals above regulatory guidelines. The NYSDEC "lowest effect level" thresholds for cadmium, copper, mercury, and nickel were exceeded in many samples. These thresholds are developed to protect aquatic biota living in sediment.
A second NYSDEC program classifies sediment into three classes (A, B, and C) depending on restrictions for disposal of dredged material. Class A is the lowest contaminant levels where disposal is unrestricted. Nearshore sediments in southern Cayuga Lake exceeded Class A thresholds for cadmium, copper, and mercury. Metals are part of the natural soil matrix, so their detection at low levels in sediments is to be expected. Elevated concentrations can reflect industrial inputs through effluent discharges, watershed runoff, and atmospheric deposition.

Sediments were also analyzed for organic compounds. Just as with the metals results, measured concentrations may be compared with regulatory guidelines established to protect designated uses of the lake ecosystem or to regulate disposal. Pesticides were detected in several of the nine sediment samples at concentrations exceeding thresholds for human health bioaccumulation, chronic toxicity for benthic (bottom) life, and wildlife bioaccumulation. The highest frequency of detectable pesticide results was associated with DDT and its breakdown products. Three samples of the top meter of sediment collected in nearshore areas exhibited elevated concentrations of polyaromatic hydrocarbons. These compounds are associated with fossil fuel combustion.

Biological community

Phytoplankton: Microscopic algae suspended in the water (phytoplankton) form the base of the food web in Cayuga Lake. The growth rate, abundance, and species composition of the phytoplankton community are affected by light, temperature, grazing pressure, and nutrient availability.

The phytoplankton community of Cayuga Lake is well-characterized. Annual succession dynamics dominate the observed variation in phytoplankton community structure. Four distinct periods are evident each year. In spring, the phytoplankton community is dominated (both numbers and biomass) by diatoms and cryptophytes. Chlorophyll *a* concentrations typically reach their annual maximum during this period. During a brief period in July large numbers of extremely small cyanophytes (blue-green algae) dominate the phytoplankton community in terms of numbers, but not biomass. From late summer through the fall mixing period, chlorophytes (green algae) dominate both numbers and biomass of the phytoplankton community. Blue-green algae gradually increase in importance over this period. During winter the community is dominated by cryptophytes.

Macrophytes: Rooted aquatic plants and algae (macrophytes) are a distinct feature of the shallow shelf areas at the southern and northern ends of Cayuga Lake. Aquatic macrophytes provide a number of important functions to lake ecosystems including stabilization, food, and habitat value. The presence of macrophytes in the littoral zone (the area between land and open water, which can also be described as that portion of the lake where rooted aquatic plants exist) is correlated with higher diversity and abundance of invertebrates, which are essential food sources for many life stages of organisms found in the lake. Macrophytes provide shelter and forage for waterfowl, invertebrates and fish. They provide habitat areas for insects and other organisms and for the spawning of many fish species. In addition, macrophytes provide habitat for young-of-the-year fish and adult sport fishes.

While important to the lake ecosystem, macrophytes can interfere with recreational uses of a lake if they become too abundant or if nuisance species dominate the flora. The species assemblage of macrophytes in Cayuga Lake has been documented at various intervals since the 1920s.

Significant changes in total biomass and species composition of macrophytes have occurred in the last decade. The abundance and dominance of *Myriophyllum spicatum* (eurasian watermilfoil), a nuisance exotic species which was dominant from the 1960s – 1980s have declined in the northern and southern study areas of Cayuga Lake. The precipitous decline in eurasian watermilfoil in the study areas has been accompanied by an increase in two native species, *Elodea canadensis* in the southern lake basin and *Vallisneria americana* in the northern shelf. This decline in dominance of eurasian watermilfoil was concurrent with the observation of the moth *Acentria ephemerella* feeding on the growing tips of this macrophyte.

In addition to herbivory, there are many environmental factors influencing the total biomass and species composition of macrophytes in Cayuga Lake. Significant storm events that deliver large amounts of sediment to the lake can affect light penetration and the littoral habitat. Invasion of lakes by the zebra mussel *Dreissena polymorpha* is associated with an increase in water clarity and expansion of littoral habitat . Zebra mussels entered Cayuga Lake through the Seneca River system and have spread from north to south. Finally, mechanical harvesting can influence the species composition along with abundance of macrophytes. Apparently, mechanical harvesting removes sufficient numbers of herbivorous larvae to suppress their effectiveness as a natural control for eurasian watermilfoil.

Zooplankton: The zooplankton community is another important component of the Cayuga Lake ecosystem. These small, motile, water column organisms graze on phytoplankton and are consumed by various life stages of fish. The Cayuga Lake zooplankton community is typical of a moderately productive north temperate lake.

Rotifers are the most abundant group, followed by cladocerans and copepods. Diversity and density of rotifers and cladocerans decreased with water depth. This pattern was reversed for copepods where the highest numbers of individuals and species were present at the deeper stations.

The zooplankton community of Cayuga Lake also includes a large number of the hypolimnetic crustacean *Mysis relicta*, the opossum shrimp. *Mysis relicta* is an important component of the Cayuga Lake food web. The species is a food source for juvenile lake trout , alewife, and smelt. Abundance of this zooplankton is considered by NYSDEC to be the facto limiting growth rate of juvenile lake trout.

Fish. The Cayuga Lake food web includes two interrelated assemblages of species, one in the shallow (littoral) zone and the second in the deep water (pelagic and profundal) zone. The littoral zone, defined as the region where light can penetrate to the sediment surface, extends from the shoreline to a water depth of approximately 20 ft. Because of the lake's shape, the littoral zone is primarily restricted to the northern and southern basins with only a narrow fringe along the eastern and western shorelines. Approximately 25% of the total surface area overlies depths of 20 ft. or less.

Most of the littoral zone is located in the northern basin, which is home to a warmwater fish community dominated by smallmouth bass. Other important predator fish in the littoral community include largemouth bass and northern pike. These species prey on yellow perch, pumpkinseeds, bluegills, rock bass, and minnows. Southern Cayuga Lake supports a spawning population of white suckers.

The deep water community is dominated by lake trout, rainbow trout, brown trout, and landlocked salmon as the top predators. Of these salmonids, only the lake trout is native to Cayuga Lake. Populations of the salmonids are maintained (or, in the case of rainbows, supplemented) by stocking. Juvenile salmonids prey on zooplankton, including *Mysis relicta*. Chiotti (1980) considers the quantity of this zooplankton to be the limiting factor for the growth and survival of stocked juvenile lake trout, Cayuga Lake's most important sport fishery. Older salmonids are piscivorous (fish eating) preying on alewives, rainbow smelt, white perch, and slimy sculpin.

The food web supporting the deep water community is relatively short: phytoplankton, zooplankton, alewife, and salmonids. A second energy pathway culminating with smelt begins with organic detritus, which is consumed by *Mysis relicta*, then by smelt. These generalized food webs do not reflect changes in food preferences with life stage and size.

Distribution of fish reflects thermal preferences, predator-prey relationships, and predictable migrations for spawning. Similar to feeding relationships, distribution is variable with life stage and season.

Nuisance organisms

The Great Lakes have been repeatedly invaded by plants and animals. Since the 1800s, at least 136 exotic aquatic organisms of all types: plants, fish, zooplankton, mollusks, and algae have been introduced. More than one-third have been introduced in the last 30 years, coinciding with opening of the St. Lawrence Seaway. Because of the hydrologic connection, many species introduced to the Great Lakes ultimately are found in the Finger Lakes.

Some nonindigenous species have long been part of the Cayuga Lake ecosystem. Rainbow smelt, alewife, white perch, common carp, and sea lamprey were introduced to Cayuga Lake as were rainbow trout and brown trout. Introduced plant species include eurasian watermilfoil, curly-leaf pondweed, and purple loosestrife. Eurasian watermilfoil *Myriophyllum spicatum* is highly visible to lake users.

Some of the most recent invaders to the ecosystem are among the most visible. *Dreissena polymorpha* (zebra mussel) and *Dreissena bugensis* (quagga mussel) have spread throughout the Great Lakes and their connecting waterways, the Finger Lakes, and many major river systems of the northeast. These mussels entered Cayuga Lake through the Seneca River in the early 1990s and have spread from north to south. By 1996, mussels were widely distributed throughout the lake, with dense populations in nearshore areas. Water suppliers, utilities, and other water users with intakes less than 10 m have found it necessary to employ control measures to minimize or prevent fouling. Proliferation of zebra mussels also diminishes the recreational suitability of the resource.

Long-term ecological effects of zebra mussels on lakes include increased water clarity and an enriched benthos (lake bottom). Mussels feed by filtering particles suspended in the water column where large quantities of organic material is pulled down from the water column to the benthos. One result is an increase in the diversity and production of all groups of benthic organisms. Periphytin and macrophytes benefit from the improved water clarity and, like zoobenthos, benefit from the increased nutrients and organic carbon found at the sediment surface. Many benthic macroinvertebrates benefit from the increased surface area created by the mussel shells. Production of benthic feeding fish can increase from the improved food supply. However, the increase in benthic production comes at the expense of the water column food web. This transfer of energy and nutrients from the water column to the benthos can lead to a fundamental shift in the food web.

Two exotic crustaceans, the predatory cladoceran zooplankton *Bythotrephes cederstroemi* (spiny waterflea) and *Cercopagis pengoi* (predatory waterflea) are recent invaders of the Great Lakes with the potential for altering the aquatic ecosystem. By October 1999, *Cercopagis* was confirmed present in Cayuga Lake, while *Bythotrephes* was not. Predation by these zooplankton on smaller cladocerans has the potential to affect the size distribution and composition of the phytoplankton community. These organisms may also affect fish populations by competing with young-of the-year fish for prey, or by becoming prey for older fish.

V. HUMAN USES

Pollutants can enter water through direct, piped and channeled discharges – point sources, or they can enter groundwater, lakes, or streams from complex transport and delivery mechanisms within the lake watershed - nonpoint sources.

Surface Runoff

Overland flow, or stormwater as it is commonly called, is generated when the capacity of the soils and vegetation to absorb water from precipitation is exceeded and water runs across the surface of the land. In clay-rich soils, the water-retention capacity is low and runoff from these soils is generated quickly. In sandy soils, a larger portion of the precipitation infiltrates the land surface and recharges the underlying groundwater system, resulting in less runoff. Urban land contributes large amounts of contamination to water bodies via stormwater runoff.

Urban areas are characterized by a higher percentage of impervious surface coverage. Therefore, the ability of stormwater runoff to transport more pollutants is magnified. This can be seen in many of the subwatersheds, especially in the downstream portions of those subwatersheds. These include the following: Glenwood Creek Area (Town of Ithaca and Town of Ulysses), Lansing Area (Town and Village of Lansing, Cayuga Heights, Town of Ithaca), Big Salmon Creek/Little Salmon Creek/Salmon Creek/Locke Creek (Town of Lansing), Virgil Creek/Fall Creek (Village and Town of Dryden, Village of Freeville, Cayuga Heights, City and Town of Ithaca), Cascadilla Creek/Sixmile Creek/Buttermilk Creek/Cayuga Inlet/West Branch/Fish Kill/Enfield Creek (City and Town of Ithaca).

Roadbank & Streambank Erosion

In recognition of the role that roadbank and streambank erosion plays in the sedimentation rates in the Cayuga Lake Watershed a Roadbank & Streambank Inventory was done from May though August 2000.

Roadbank Inventory

The northwest portion of the watershed has relatively few problems with roadbank erosion with a few exceptions in Bloomer/Mack Creeks Area and the Sheldrake Creek subwatershed. The northeastern portion of the watershed has more significant roadbank erosion. Generally, the closer the road ditches are to the lake the more erosion is occurring mainly due to the steep gradients from the upland portions of the watershed down to the lake. This is demonstrated in the numerous road ditches classified as “very severe” in the King Ferry area. The same is true further south in the Lansing area. The southwestern portion of the watershed has some very severe erosion occurring along the road ditches in the Spring Brook, Taughannock Creek, Enfield Creek, and Willow Creek area. The large subwatersheds in the southern portion of the watershed with the exception of the Virgil, Cascadilla, and Buttermilk Creek subwatersheds have numerous road ditches classified as "very severe".

Streambank Inventory

The streambank data collected from the Cayuga Lake watershed displays various trends regarding erosion and sedimentation ultimately affecting water quality in the lake. Minor erosion is occurring along the western and eastern subwatersheds north of the Taughannock Creek subwatershed and the Salmon Creek subwatershed. The direct drainage basins on the southern end of the lake appear to pose little problems in regard to erosion. More appreciable erosion is apparent in the northeastern subwatersheds in Yawger Creek, Great Gully and Lavanna Area subwatersheds. Taughannock, Bolter, and Spring Brook subwatersheds also show a trend of appreciable erosion. The Salmon Creek major subwatershed (Salmon, Little Salmon, and Big Salmon Creeks) is classified as the low end of severe. The large subwatersheds on the southern end of the lake with the exception of the direct drainage basins are responsible for appreciable loads of sediment flowing into the lake. Fall, Virgil, and Sixmile Creeks are all categorized as moderately severe with a few very severe sites. The Cayuga Inlet is characterized as very severe and contains some of the highest stream ranks in the watershed.

Underground and Above Ground Storage Tanks

Chemical and petroleum products held in storage tanks can pose a significant threat to water quality. The average life of an underground storage tank in more acid soils (e.g. Tompkins County) is approximately 15 years. Leaking storage tanks can be significant sources of oil, fuel, and volatile organic compound (VOC) contamination. These contaminants may move into surface-water resources with groundwater flow. In the Cayuga Lake Watershed there are over 340 registered storage tanks sites, along with many more unknown tanks, containing petroleum and chemicals (NYSDEC, 1998a&b). These are dispersed throughout the watershed, but exist primarily in the southern part of the watershed.

Hazardous Materials

Any land use that results in the generation, use, or storage of materials classified as hazardous may be a source of contamination to ground and surface water. Hazardous materials are classified as substances that pose a danger to living organisms, materials, structures, or the environment by explosion or fire hazards, corrosion, toxicity to organisms, or detrimental effects. Based on NYSDEC data, there are several inactive hazardous waste sites in the watershed, most of these are along the southern end of the lake. These include an old chemical storage site which has leached into the groundwater and a low level radioactive site at Cornell, and a site in downtown Ithaca with buried coal tar and old city dumps.

Hazardous Spills

Hazardous spills can occur in a number of ways including leaking underground storage tanks, materials transfer, and materials transport. In the Cayuga Lake Watershed most spills have occurred in the southern portion, although there are many occurrences of spills throughout the watershed. Of the approximately 550 reported hazardous spills recorded in the watershed over the past 15 years, 360 were on land, 15 in sewers, 105 into groundwater, 60 directly into surface water, and 10 into the air (NYSDEC, 1998c).

Industrial Sources

There are over 600 industrial operations in the watershed. The categories of industrial sources include general industrial, industrial pipeline, material stockpiles, mining operations, transport and transfer stations, and well drilling operations. Other than wells and well drilling operations, most of the industrial operations are located in the southern portion of the watershed.

NYSDEC lists over 330 dry, brine, and gas development and extension wells in the watershed. These wells are fairly well dispersed throughout the watershed, with a pronounced concentration of over 70% in the northeast portion in the Aurelius, Fleming, and Springport area. These are mainly active gas wells. Approximately 5% of the wells in the watershed are brine wells, almost all of which are in the Town of Lansing. Approximately 18% of the wells in the watershed are dry wells, approximately 25% of which are plugged and abandoned.

Sand and gravel mining can pose a threat to water resources. Because of their relatively permeable nature, sand and gravel deposits are generally coincident with recharge areas. In order to mine these deposits, the topsoil is first removed, eliminating an important buffer zone between the ground surface and the underlying aquifer. Lowering the ground surface decreases the relative depth of the water table, thereby making it more susceptible to contamination from mining apparatus and vehicles. The loss of vegetation exposes sediment, making it more easily removable by wind and surface water runoff. Based on NYSDEC data, there are approximately 30 mines in the watershed. The vast majority of these (all but 3) are sand and gravel mines. The majority of the mines are in the southern and southeastern portions of the watershed.

There are two permitted discharges of noncontact cooling water to Cayuga Lake. AES-Cayuga (formerly known as Milliken Station) is a 387 megawatt, coal-fired power plant located 13 miles north of Ithaca on the eastern shore of the lake. This plant is permitted to circulate water at a rate of 10.67 cubic meters per second (169,000 gallons per minute). Water is drawn from a depth of 46 feet and returned to the surface. The temperature of the cooling water increases approximately 8.6 °C as it flows through the AES-Cayuga facility. The temperature of the water as it is returned to the lake is variable. It depends on the water temperature flowing in. At the intake the temperature of the lake fluctuates between 4 – 20 °C over the year. The temperature of the return flow is therefore 13 – 29 °C, which is almost always warmer than background conditions at the outfall.

A second noncontact cooling water discharge to Cayuga Lake has been permitted and will be on line in the summer of 2000. Lake Source Cooling (LSC) is a 29.4 megawatt heat exchange facility located on East Shore Drive in Ithaca. The LSC facility is permitted to circulate water at a peak rate of 2 cubic meters per second (32,000 gallons per minute). Actual flows will be variable, based on the demand for campus cooling, and will be much lower during winter. LSC draws water from a depth of 250 feet where it is cold year-round. The temperature of the water increases approximately 3.9 °C (winter) to 8.3°C (summer) as it flows through the heat exchange facility. During winter, the return flow will be approximately 8° C, which is warmer than the lake. During summer, the LSC return flow will be approximately 13° C, which is cooler than water in the shallow nearshore area where the water flows back to the lake. The outfall has a diffuser to insure rapid mixing of the return flow with lake water and minimize the plume of cooler or warmer water.

Potential environmental impacts of LSC have been the focus of research, monitoring, debate, regulatory scrutiny, and judicial review since 1994. The project reduces energy used in cooling by more than 80% and enables Cornell to accelerate replacing CFCs and aging equipment. The benefits of using the lake's cool water as a renewable resource have been weighed against potential adverse impacts of adding heat and circulating water from deep in the lake to the surface.

Of greatest concern has been phosphorus (P) transfer to the upper waters (the region of plant and algal growth) during the summer, when the lake waters do not naturally mix. LSC will not add phosphorus to the lake, but the transfer of phosphorus present in the lake's lower waters represents an additional source during the summer recreational season. Phosphorus is the limiting nutrient for algal growth in Cayuga Lake, and its transfer to the shallow southern lake, where concentrations are already elevated, has been a serious issue to the community. Phosphorus transfer by LSC is estimated at 2.9 kg P per day from May to October (assuming LSC is at its maximum permitted flow and concentrations in the lower waters are at their annual peak). For comparison, the two large tributaries to southern Cayuga Lake deliver 13.3 kg P per day during this period, and the two wastewater plants can discharge up to 45.4 kg P per day. During the remainder of the year the lake waters mix naturally.

The majority of scientists reviewing the LSC project concur with the conclusions of the Environmental Impact Statement that additional algal growth associated with phosphorus transfer of this magnitude will not be discernible. In fact, many reviewers concluded that transfer of cool, clear water from deep in Cayuga Lake will help improve water quality in the shallow southern lake basin. Others remain concerned that phosphorus in the lake's lower waters will be immediately available to the plant community and will stimulate algal growth near the outfall.

Because of the uncertainties associated with this innovative project and the current water quality conditions of southern Cayuga Lake, the LSC permit has a number of conditions for monitoring and assessment. There are "reopener" clauses in the 5-year permit requiring Cornell to take action if the LSC return flow causes water quality degradation. Cornell has committed to sharing their monitoring data with the community. Because of the level of concern regarding the LSC discharge, monitoring and assessment of its impacts will be reflected in the Cayuga Lake Watershed Management Plan.

Commercial Sources

Higher risk potential commercial sources of contamination in the watershed include airports and abandoned airfields, auto repair shops, boat yards and marinas, car dealerships/services, car washes, campgrounds, cemeteries, funeral homes and services, gasoline service stations, golf courses, hardware and lumber stores, horticultural practices including garden nurseries, and florists, laundromats and dry cleaners, print shops and publishing operations, medical institutions, railroad tracks and yards and veterinary services. There are approximately 50 auto repair shops in the watershed. These are dispersed throughout the watershed and are especially prevalent in the southern portion. There are approximately 25 boat yards and marinas in the watershed. These are fairly well dispersed, generally directly adjacent to the lake. There are approximately 40 car dealerships/services in the watershed, the majority of which are in the southern portion. There are approximately 170 cemeteries in the watershed. They are fairly well dispersed. There are approximately 55 gasoline service stations in the watershed. While there are gasoline service stations throughout the watershed, they tend to be most dense in and around the population centers in the southern portion of the watershed. There are approximately 15 horticultural operations in the watershed. They are fairly well dispersed. There are approximately 20 laundromats and dry cleaning operations throughout the watershed, the majority of which are in the southern portion.

Municipal Sources

Cayuga Lake is a public and private drinking water supply. Numerous communities and hundreds of households depend on the lake and its watershed as a drinking water source from both surface and ground waters. The largest public surface water supplies are located at the southern end of the watershed. These include a portion of the water system for the City of Ithaca, which draws water from Six Mile Creek, and the Southern Cayuga Lake Intermunicipal Water Commission at Bolton Point, which serves five municipalities and Cornell University. Other smaller surface water systems include the Village and Town of Seneca Falls and the Villages of Cayuga and Aurora. The majority of systems using groundwater have a retail population of less than 1,000. The only groundwater systems with a retail population over 1,000 are municipal systems located in Union Springs, and the Villages of Dryden, and Trumansburg.

Treated wastewater (effluent) from several municipal treatment plants is discharged to Cayuga Lake and its tributaries. A total of 15 million gallons of treated wastewater is permitted to flow into the lake and its tributaries each day from nine municipal treatment plants. Quality and quantity of the discharges remain relatively constant throughout the year, although higher flows tend to occur in the spring. The quantity and quality of wastewater (and other) discharges are closely regulated by NYSDEC to ensure that receiving water quality meets or exceeds standards associated with its designated use

The communities of Ithaca, Dryden, Cayuga Heights and Lansing recently submitted an application for funding assistance with upgrades and expansion of their municipal wastewater treatment systems. The intermunicipal proposal of August 1999 includes expansion of the service area into Lansing, with wastewater flows from the new service area directed to the Cayuga Heights plant. Excess flows from Cayuga Heights would be directed to the Ithaca Area Wastewater Treatment Plant, which serves the City and Town of Ithaca and the Town of Dryden. The flow capacity of this plant would be increased from 10 to 13 million gallons per day (mgd).

One element of the proposal is to increase the phosphorus removal capacities of both the Ithaca Area and Cayuga Heights treatment plants by adding filtration to the treatment process. Both plants currently hold a total phosphorus (TP) limit of 1.0 mg/l in their State Pollution Discharge Elimination System (SPDES) permit, consistent with the requirements of the International Joint Commission for wastewater treatment plants within the Great Lakes basin with a capacity greater than 1 mgd. Performance of the Ithaca Area Wastewater Treatment Plant is well below the 1 mg/l phosphorus (TP) limit, where average effluent concentrations are in the range of 0.5 – 0.6 mg/l. The Cayuga Heights plant has historically operated close to its permit limit of 1 mg/l for TP although improvements have been made in recent months as part of a 1998 wastewater improvement project.

NYSDEC policy for new discharges to lakes can require an effluent limit of 0.5 mg/l for TP, recognizing the central role of phosphorus in eutrophication of inland lakes. When existing plants request an increase in permitted flow, it is NYSDEC policy to hold the discharge to the existing mass limit for TP, thus reducing allowable concentration proportional to the flow increase.

With filtration, both Cayuga Heights and the Ithaca Area wastewater treatment plants will be able to meet or exceed a TP limit of 0.5 mg/l. Effluent concentrations from filtration can be 0.2 mg/l or less, depending on the amount of chemical addition and flow rates through the filters.

Outside of the few sewer districts there is extensive usage of septic systems. The highest densities of septic systems are in the southeast and southwest sides of the lower one third of the lake and the southern portion of the watershed. The effectiveness of on-site wastewater treatment is highly dependent on the soils, slopes, distance to surface and groundwater, and system use and maintenance. Much of the soils in the watershed have severe to very severe septic usage limitations. The NYSDEC Priority Waterbodies List (PWL) lists septic systems as a source of pollutants in segments of Cayuga Lake, Fall Creek, Lake Como, Cayuga Inlet, and Six Mile Creek.

Groundwater and surface water contamination from road salt application and storage occurs when the salt dissolves in precipitation and either infiltrates though topsoil into the water table or runs off into surface water. This can effect water quality including elevation of chloride levels. Important storage considerations include type of material, and type of storage. Most of the material used in the watershed is sand and salt. However, some municipalities use other materials such as cinders, IceBan, and calcium chloride. In the Cayuga Lake Watershed approximately 58% of deicing material is stored in enclosed facilities. Sixty-two percent of deicing material is stored on concrete, asphalt, shale or pavement. The rest is stored on the ground.

Important spreading considerations include ingredient ratio, amount per road mile, total amount per season, and total road miles. The average total amount of deicing material spread in the Cayuga Lake Watershed exceeds 30,000 tons per year (G/FLRPC).

Municipal waste landfills and dumps represent significant sources of metals, nutrients, pesticides, pathogens, and synthetic organic compounds. Based on NYSORPS data, municipal waste sites are fairly evenly dispersed throughout the watershed. Many of these sites were not properly sited or constructed. Their density is somewhat greater in the southern portion of the watershed, some of which are adjacent to the lake while others are close to tributaries.

Agricultural Sources

For the purposes of the Preliminary Watershed Characterization, agricultural sources were broken into two categories: plant agriculture and livestock. Plant agriculture was then further broken into the categories of field and truck crops, nursery and greenhouses, orchard, and vineyard. The livestock category includes cattle, calves, hogs; dairy products; poultry and poultry products; other livestock including donkeys and goats; aquatic farms; horse farms; sheep and wool; and fish, game and wildlife preserves.

Agriculture accounts for about 50% of the land use in the watershed when considering all categories including agricultural vacant land. Livestock farming accounts for over 20% of the land in the watershed. Plant agriculture accounts for over 15% of the land in the watershed. The vast majority of the livestock category is in dairy operations with a high density of these operations on the eastern side of the watershed. The primary plant agricultural category is in crop operations, much of which is for livestock feed. These operations are most dense in the eastern portion of the watershed as well (NYSORPS).

The primary agricultural nonpoint source pollutants are nutrients, sediment, animal wastes, salts, and pesticides. Agricultural activities also have the potential to directly impact the habitat of aquatic species through physical disturbances caused by livestock or equipment, or through the management of water. The PWL, which frequently has no quantitative backing particularly with regard to nutrient loading and pesticides, indicates nutrient loading from agriculture in the following tributaries to the lake: Yawger Creek, Big Salmon Creek, Little Salmon Creek, Dryden Lake, Lake Como, Fall Creek, Cascadilla Creek and Six Mile Creek. The PWL lists sediment as a type of pollutant in portions of the following tributaries to Cayuga Lake: Yawger Creek, Bolter Creek, Big Salmon Creek, Little Salmon Creek, Fall Creek, Lake Como, Cascadilla Creek, Cayuga Inlet, and Six Mile Creek. The PWL lists pesticides as a type of pollutant in Six Mile Creek and Cayuga Lake.

Tourism and recreation

The Cayuga Lake Watershed has numerous opportunities for residents and tourists to enjoy the amenities of the lake and the surrounding area. The natural resources of the area allow for water-based recreation including fishing, boating, and swimming. Cruises and charter boats also operate seasonally offering access to the water and activities for tourists. Marinas and boat launches are located along the lake with the largest concentration found at the southern end of the lake near Ithaca. The agricultural tradition of the watershed, that continues today, serves as the foundation for a number of "agri-tourism" businesses, most notably wineries. In addition, a rich cultural heritage is also present through museums and historic sites.

There are numerous federal, state and local parks, forests, sanctuaries, refuges, and wildlife management areas in the watershed providing areas for camping, hiking, picnicking, passive use. The northern part of the Cayuga Lake Watershed includes a small portion of the Montezuma National Wildlife Refuge. The City of Ithaca, at the southern end of the lake, complements the watershed’s predominantly rural character. In addition to activities reserved for the warmer summer months, cross country skiing trails and local parks’ winter programs offer tourists and residents year-round recreation opportunities.

VI. REGULATORY/ PROGRAMMATIC ENVIRONMENT

Federal

The Clean Water Act (CWA) was passed in 1972 and signaled the creation of centralized federal legislation to protect and restore the biological, chemical, and physical properties of the nation’s water. This protection was to be achieved though legislation requiring a permit for the discharge of pollutants, the encouragement of best management practices to control pollution, and funding for the construction of sewage and wastewater treatment plants and facilities. The act was amended five years later and placed more stringent controls on the discharge of toxic materials and allowed states to assume responsibility over federal clean water programs. The primary focus of the CWA and the 1977 amendments was the prevention of pollution discharges from point sources. In 1987 the act was again amended, this time to focus on nonpoint sources of pollution.

Phase I of the USEPA's storm water program was promulgated in 1990 under the CWA. Phase I relies on National Pollution Discharge Elimination System (NPDES) permit coverage to address storm water runoff from: (1) "medium" and "large" municipal separate storm water systems (MS4s) generally serving populations of 100,000 or greater, (2) construction activity disturbing 5 acres of land or greater, and (3) ten categories of industrial activity. In NYS NPDES permitting is under the purview of the NYSDEC, which issues a State Pollution Discharge Elimination System (SPDES) permit.

The Storm Water Phase II Final Rule was published on December 8, 1999. The permitting authority of the Storm Water Phase II Rule will be phased in over a 5-year period. The Phase II program expands the Phase I program by requiring additional operators of MS4s in urbanized areas and operators of small construction sites, through the use of NPDES permits, to implement programs and practices to control polluted storm water runoff.

Phase II is intended to further reduce adverse impacts to water quality and aquatic habitat by instituting the use of controls on the unregulated sources of storm water discharges that have the greatest likelihood of causing continued environmental degradation. The environmental problems associated with discharges from MS4s in urbanized areas and discharges resulting from construction activity.

Section 404 of the CWA establishes a program to regulate the discharge of dredged and fill material into waters of the United States, including wetlands. EPA and the Army Corps of Engineers (Corps) jointly administer the program. In addition, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and State resource agencies have important advisory roles. Activities in waters of the United States that are regulated under this program include fills for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming and forestry.
The basic premise of the program is that no discharge of dredged or fill material can he permitted if a practicable alternative exists that is less damaging to the aquatic environment or if the nation's waters would be significantly degraded. In other words, when you apply for a permit, you must show that you have a) taken steps to avoid wetland impacts where practicable; b) minimized potential impacts to wetlands; and c) provided compensation for any remaining, unavoidable impacts through activities to restore or create wetlands.

The Safe Drinking Water Act (SWDA) was passed in 1974 to protect drinking water supplies from harmful contaminants. The legislation attempts to provide safe drinking water through primary drinking water regulations, underground injection control regulations, and protection of sole source aquifers. In 1986 the act was revised to speed up implementation and included additional provisions for regulating contaminants, filtration systems, distribution systems, and wellhead protection systems. The SWDA establishes both health-related (primary) and nuisance-related (secondary) standards for public drinking water. Under the original legislation, the EPA set primary standards for 25 contaminants. The 1986 amendments required the EPA to include an additional 48 contaminants, raising the total number of chemicals regulated in drinking water to 83. In August 1996, the act was amended to include a program that requires states to monitor and evaluate the quality of sources of drinking water supplies through a state-driven Source Water Assessment Program (SWAP). In addition, more stringent standards for drinking water and reporting of contaminant levels by water providers to their customers were also included.

In 1997, twenty-five years after the passage of the CWA, the Clean Water Action Plan (CWAP) was launched. The CWAP provides funding for programs developed by the EPA and USDA in conjunction with other federal agencies and state and local governments focusing on restoring and sustaining the quality and health of water resources.

The Environmental Quality Incentives Program (EQIP) is a USDA-NRCS initiative authorized by the 1996 Farm Bill that provides farmers with technical, financial, and educational assistance to address soil, water, and natural resource concerns in an environmentally beneficial and cost-effective manner. A conservation plan is required to receive EQIP funding. EQIP addresses natural resource concerns through the implementation of structural, vegetative, and land use practices such as manure management facilities, abandoned well capping, tree planting, filter strips, nutrient, pest, and grazing management, and wildlife habitat protection and enhancement. Agricultural producers enter into five-to-ten year contracts with federal funding limited to $10,000 per year with a maximum of $50,000 for the total contract.

At this time, Cayuga County is the only county in the watershed to receive EQIP funding. The three-year program is being overseen by the Cayuga County SWCD and exceeds $800,000 in funding for individual contracts with 62 farms in the watershed. The emphasis of the program is on developing and implementing Best Management Practices (BMPs) that reduce nutrient loading and sediment erosion. The Tompkins County SWCD is seeking EQIP funding for farms in the Fall Creek subwatershed. Other county SWCDs in the watershed have applied for EQIP funding every year, but have yet to receive any moneys.

The Agricultural Environmental Management (AEM) program assists farmers in identifying environmental issues on their farms and implementing measures to maintain their economic viability while simultaneously protecting natural resources. AEM involves a five-tier process of one-on-one consultation between farmers, members of agricultural agencies, and representatives of agri-business at the local level. Agricultural agencies involved in AEM include SWCDs, NRCS, Cornell Cooperative Extension, and the Farm Service Agency. Farmers voluntarily enter into these partnerships and remain the primary decision-maker throughout the AEM process.

In addition, the AEM program also addresses Animal Feeding Operations (AFOs). AFOs are agricultural operations where animals are raised and maintained in confined areas for 45 days or more in any 12-month period and where crops, vegetation, or other forage growths are not sustained over any portion of the lot or facility in a normal growing season. AFOs contribute to pollution through the carrying of nitrogen, phosphorus, pathogens, sediment, hormones, antibiotics, ammonia, and other harmful substances to water bodies.

AFOs are considered Concentrated Animal Feeding Operations (CAFOs) if they meet the standards of AFOs and there are more than 1,000 animal units at the facility or there are 301-1000 animal units and the facility directly discharges into a waterbody or through the confinement area via a manufactured conveyance. CAFOs are point sources of pollution under the National Pollution Discharge Elimination System (NPDES) and are regulated under Section 301 of the CWA.

The Cayuga County SWCD has received over $500,000 in funds through the Bond Act to work on animal waste management. In addition, the SWCD has received an EPA grant to demonstrate the use of drag hose applications in animal waste management. Several farms in the Cayuga Lake Watershed are currently receiving technical and financial assistance through this grant. Windmills have been installed on two animal waste pits to reduce the odor produced by these facilities. Currently, six rotational grazing programs have been developed, with four now implemented, for livestock operations in the watershed. Stream control plans have been developed for six sites in the watershed and will be implemented over the next year.

The Cortland County SWCD has applied for an implementation grant to institute BMPs on three farms in the Virgil Creek subwatershed after completing plans. Nutrient management programs are produced in combination with other programs as needed, most notably as part of the AEM BMPs. A nutrient management program has been developed and implemented for at least one farm in the Cortland County portion of the watershed.

According to the Seneca County SWCD, no requests for AEM plans have been requested from farms in the eastern portion of the county within the watershed. Private consultants currently design nutrient management programs for Seneca County farms. Many of these nutrient management programs began being developed and undertaken before CAFO/AFO regulations were mandatory. At this time, the Seneca County SWCD has received no requests for nutrient management program assistance.

Funding from the NYS Agricultural Non-Point Source Abatement and Control Grant Program is currently being sought to assist in the production of AEM plans for farms in the Taughannock Creek subwatershed at the southeastern end of the Town of Hector in Schuyler County. Three farms in Hector have received agricultural waste management plans that address manure storage design, silage leaks, barnyard pad runoff, and dairy operations in an attempt to reduce environmental risks as part of AEM plans. Nutrient management programs are done by private consultants throughout the county and if requested are produced for farms within the watershed.

Through AEM, the Tompkins, Cayuga, and Cortland SWCDs have completed surveys and worksheets for farms in the Fall Creek subwatershed. The Tompkins County SWCD has also completed surveys and worksheets for the Sixmile Creek and Salmon Creek subwatersheds. At present there are no major water quality problems and the current thrust is to assist farms in implementing BMPs to meet CAFO/AFO requirements. According to the Tompkins County SWCD, which administered the enabling grant, many of the farms have or are currently implementing portions of their Agricultural Waste Management Plans to meet compliance standards for CAFO/AFO regulations. Within the Fall Creek subwatershed over 120 farms covering approximately 43,000 acres were surveyed. Existing nutrient management programs are incorporated in the AEM plans. However, a comprehensive nutrient management program planning grant is currently being sought for the Tompkins County portion of the Cayuga Lake Watershed.

State

The NYDOS, Division of Coastal Resources provides financial and technical assistance and promotes initiatives at the local, regional, and state level to protect and enhance the coastal ecosystems and economies of New York State.

The NYSDEC attempts to enhance water quality through a number of activities including technical assistance for prevention, education, and monitoring and financial assistance for demonstration programs, improvement of existing facilities, and the construction of new ones. The NYSDEC provides technical assistance and funding through watershed management, dissemination of resources on best management practices, water quality monitoring, and assessing waterbodies throughout the state.

As part of the CWAP, the NYSDEC has developed the New York State Unified Watershed Assessment Program. Each of the watersheds within the state has been classified into one of four categories based on groundwater and surface water quality and impairments. The watersheds are then ranked according to the level of impairments and targeted for improvement based on these rankings. The Seneca-Oswego Basin is in Category I which includes watersheds in need of restoration (do not now meet, or face imminent threat of not meeting clean water and other natural resource goals).

NYSDEC requires that every point source discharger obtain a permit in order to legally discharge sanitary, industrial, or commercial wastewater. The permit is a comprehensive legal document, and all of its provisions and conditions are enforceable under the law. Under SPDES, NYSDEC reviews permit applications to develop the limits for types and quantities of pollutants in the effluent. The permit also includes the schedules and conditions under which discharges are allowed. Owners or operators of facilities must treat wastewater in order to meet the limits listed in their SPDES permit. In the case of municipal facilities, permits also require industries discharging into the municipal collection system to pre-treat their wastes. Compliance and self-monitoring reports are a major part of this program. Permits are reviewed and reissued every five years.

The State Environmental Quality Review Act (SEQRA) is a preventive measure that requires the completion of an Environmental Impact Assessment (EIA) and Environmental Impact Statement (EIS) for proposed state and local development. SEQRA requires investigation into alternative actions and the mitigation of harmful effects of the proposed development. Potential nonpoint source pollution can be remediated through revised design or other measures.

The NYSDOH monitors the impacts of NPS as it relates to the health of the citizens of New York through water quality monitoring and reporting programs. The New York Public Health Law includes statutes regulating the protection of public water supplies from contaminants due to source and nonpoint source pollution. The commissioner of the NYSDOH and commissioners of County DOH's determine violations and subsequent penalties.

As mentioned above, the 1996 amendments to the SWDA require states to evaluate the quality of sources of public drinking water. Beginning in 1998 and continuing through 2001, the NYSDOH will administer the SWAP to aid local and state efforts to develop and implement strategies to protect drinking water supplies from both point and nonpoint source pollutants. Under the enabling legislation and the SWAP, the NYSDOH is responsible for overseeing public water supply supervision and wellhead protection among other programs.

County

Each county in the watershed has an active water quality coordinating committee (WQCC) or, in Tompkins County, Water Resources Council (WRC). The purpose of these organizations is to integrate the diverse point/nonpoint source water quality pollution control and abatement programs of various county, regional, state, and federal agencies and organizations into a coordinated, comprehensive, and effective inter-agency approach at the county level.

WQCCs and WRCs provide a forum for involvement in water resources planning and management, and more efficient use of the limited resources available.

As stated earlier, each county has a SWCD responsible for implementing the NYS Agricultural Nonpoint Source Abatement and Control Program. The New York Soil and Water Conservation Law administered by the S&WCC requires owners of agriculture, livestock, or timber producing lands to apply to their respective county's SWCD for a soil and water conservation plan. The SWCD is obligated to produce such a plan upon request by the owner of the land, but there is no penalty for not implementing the plan upon its completion. The Agricultural Nonpoint Source Abatement and Control Program is often included as part of the agricultural environmental management program that produces such plans.

Other countywide ordinances, laws, plans, and programs that address NPS are also in place within the watershed. The *Cayuga County Sanitary Code* requires periodic inspection of all septic systems within the watershed. Septic system failure is a major health concern and results in human contact with possibly infectious organisms. In Seneca County a countywide drainage plan assists in the management of NPS through standards set to protect and enhance water. Through the 1994 *Watershed Protection Law of Schuyler County*, NPS management is attained through regulation and enforcement of sewage disposal and wastewater treatment systems throughout the county. Provisions are stipulated for the discharge and disposal of sewage and the design, construction, and certification of wastewater treatment facilities.

All five of the six counties in the watershed have planning boards or commissions responsible for conducting reviews and issuing approval for proposed development. The Tompkins County Planning Department, under provisions of their Charter, is responsible for reviewing development proposals. Although they do not have a planning board or commission at the county level, they do have a Planning Advisory Board that assumes the functions of a planning board. Cayuga, Cortland, Schuyler, and Tompkins Counties each have an environmental management council while Tioga County has a conservation board. These groups monitor and advise on issues related to development and sustaining/improving the environmental character of their respective counties. None of the counties in the watershed currently have sediment and erosion control laws or vegetation retention laws.

Countywide comprehensive plans are in place in Cortland, Schuyler, Tompkins, and Tioga Counties and Cayuga County currently has a land use plan. Seneca County has prepared a comprehensive plan, but at this time it is yet to be adopted. In addition to its comprehensive plan, Tioga County has a future land use plan and an agriculture and farmland protection plan. The *Tioga County Agriculture and Farmland Protection Plan* focuses on retaining and building upon the economic benefits of agriculture in the county through more viable farming practices. Tompkins County has an approved Farmland Protection Plan. Table 5.2 presents the county regulations and controls in the watershed that have an effect on the reduction of NPS in the watershed.

Municipal

Most of the programs, ordinances, and regulations directly related to NPS are administered, prepared, monitored, and enforced at the federal, state, and county levels. These programs involve a great deal of participation at the local level by municipal boards and elected officials, citizens, and businesses. While not always directly related to NPS, land use regulations and controls at the municipal level play an important part in controlling and reducing NPS.

Some municipalities do have committees and boards that include the reduction of NPS as part of their focus. The Town of Caroline in Tompkins County is the only municipality in the watershed with a committee that assesses and provides guidance on actions developed for watershed protection in the town. Conservation boards have been assembled and operate in the Village of Interlaken, Town of Ithaca, and Village of Trumansburg.

Municipal drainage plans are currently in place in the Village of Interlaken and Town of Newfield. The Village of Aurora and Town of Genoa each have sediment and erosion control laws. At present, the Village of Lansing has a drainage plan, sediment and erosion control laws, and vegetation retention laws included as part of its comprehensive plan.

Of the 40 municipalities in the Cayuga Lake Watershed that returned the *Municipal Land Use Regulation and Control Survey*, 27 have zoning, 17 have comprehensive plans, 26 have subdivision ordinances, and 23 have adopted other plans or ordinances (G/FLRPC).

Other

The Cayuga Lake Watershed Network (CLWN) is a community-based organization made up of citizens, businesses, associations, agencies, and local governments that advocates for a healthy and sustainable Cayuga Lake watershed. Anyone who lives, works, or plays in the watershed is invited to participate. The CLWN seeks to promote understanding of how to maintain and improve the ecological health, economic vitality, and overall beauty of the watershed environment. The CLWN provides education by encouraging individual stewardship throughout the watershed by raising awareness of watershed concerns, communication by providing an interactive, responsive forum that strives for the discovery and exchange of information, and leadership by acting as a proactive advocate for an economically sustainable and ecologically balanced watershed. Additionally, the Fall Creek Watershed Committee is made up of concerned citizens within that subwatershed.

VII. FINDING OF DESIRED STATE (Public Participation Efforts)

Over the past three years there have been several planned opportunities for the public to voice their interests and concerns on issues affecting the Cayuga Lake Watershed. These events include the following:

- 1997 Finger Lakes-Lake Ontario Watershed Protection Alliance Conference
- Neighbors Around the Lake Watershed Mini-Conference I
- Cayuga Lake Watershed Network Stakeholder Survey
- Neighbors Around the Lake Watershed Mini-Conference II
- Intermunicipal Organization Water Quality Issues Identification

Although the composition of all the public input sessions were different, all included individuals who live, work, study, or recreate in the watershed. There are noticeable similarities in the issues, concerns, interests and visions that people have for the watershed including the following:

- Use of the land
- Quality of the water for uses such as drinking, fisheries, habitat, swimming, and recreation
- Economic and tourism sustainability
- Education
- Wastewater management
- Multiple uses of the lake
- Lake access
- Development pressure
- Stormwater runoff and erosion and sediment control
- Loading of nutrients, bacteria, chemicals, and metals
- Weed control
- Exotic species
- Water level

VIII. NEXT STEPS

The Preliminary Watershed Characterization is part of the Cayuga Lake Watershed Management Plan process. The Characterization will act as the basis for both the existing state of the Cayuga Lake Watershed and potential implementation of the Findings. Additional locally driven work will commence toward the development of a consensus driven desired state of the Cayuga Lake Watershed along with a consensus driven Watershed Management Plan as a guide for implementation to get from the existing state to desired state.

References

Chiotti, T.L. 1980. A Strategic Fisheries Management Plan for Cayuga Lake. Bureau of Fisheries, Division of Fish and Wildlife, NYSDEC.

Genesee/Finger Lakes Regional Planning Council. 1999. Road Deicing & Storage Inventory.

Genesee/Finger Lakes Regional Planning Council. 1998. *Municipal Land Use Regulation and Control Survey*.

Genesee/Finger Lakes Regional Planning Council. 2000. Roadbank & Streambank Inventory Project.

Jeer, S., Lewis, M, Meck, S., Witten, J. and Zimet, M. 1999. *Nonpoint Source Pollution: A Handbook for Local Governments*. American Planning Association, Planning Advisory Service, Report No. 476.

Miller, Todd S. 1988. *Unconsolidated aquifers in upstate New York - Finger Lakes sheet*: U.S. Geological Survey Water Resources Investigation Report 87-4122, 1 sheet, scale 1:250,000.

New York State Association of Regional Councils. 1997.*Population Projections to 2030, New York State and Its Counties*.

NYSDEC, 1998a. *Chemical Bulk Storage Database.*

NYSDEC. 1998b. *Petroleum Bulk Storage Database*.

NYSDEC. 1998c. *Spills Database*.

NYSDEC. 1998d. *Inactive Hazardous Waste Sites Database*.

NYSDEC, 1998. *Mined Land Database*.

NYSDEC. 1999. *New York Natural Heritage Program Species List for Cayuga Lake Watershed*.

NYSDEC. 1999b. Wells. NYSDEC Division of Mineral Resources.

NYSDEC, Division of Water. 1996. *The 1996 Priority Waterbodies List for the Oswego-Seneca-Oneida River Basin*.

New York State Office of Real Property Services, 1998. *Real Property Services Database.*

Northeast Regional Climate Center. 1999. *Climate, Ithaca, NY*. Department of Soil, Crop and Atmospheric Sciences, Cornell University.

Tompkins County Soil & Water Conservation Distinct. *Fall Creek Watershed Agricultural Land Use Practices*. Tiers I & II Survey.

USDA, Soil Conservation Service in cooperation with Cornell University Agricultural Experiment Station. 1972. *Seneca County Soil Survey*.

USDA Forest Service, 1993. *Forest Statistics for New York: 1980-1993*.

US Department of Commerce. 1990. 1990 US Census of Population and Housing STF3.

USDI, USGS , NYSDEC. 1975. *Chemical Quality of Ground Water in the Oswego River Basin, New York* Cayuga Lake Basin and Wa-Ont-Ya Basin Regional Water Resources Planning Board, ORB-3.

USGS. 1998. *Land Cover*. EROS Data Center.

Glossary of Acronyms

ACP--- Agricultural Conservation Program
ASCS---Agricultural Stabilization and Conservation Service
BOD--- Biochemical Oxygen Demand
BLM--- Bureau of Land Management
BMP--- Best Management Practice
CBS--- Chemical Bulk Storage
CCE--- Cornell Cooperative Extension
CERCLA---Comprehensive Environmental Response, Compensation and Liability Act
CLWN---Cayuga Lake Watershed Network
CNYRPDB---Central New York Regional Planning & Development Board
CPA--- Conservation Priority Area
CREP---Conservation Reserve Enrollment Program
CRP--- Conservation Reserve Program
CSGWPP---Comprehensive State Ground Water Protection Program
CSO--- Combined Sewage Overflow
CWS--- Community Water System
CWA--- Clean Water Act
CWSRF---Clean Water Act State Revolving Fund
CZARA---Coastal Zone Act Reauthorization Amendments
DBP--- Disinfection By-Products
DOD--- Department of Defense
DOE--- Department of Energy
DOI--- Department of Interior
DOT--- Department of Transportation
DWSRF---Drinking Water State Revolving Fund
EPA--- Environmental Protection Agency
EPCRA---Emergency Planning and Community Right-To-Know Act
EIS--- Environmental Impact Statement
FIFRA---Federal Insecticide, Fungicide and Rodenticide Act
FOLA---Federation of Lake Associations
FSA--- Farm Service Agency
GIS--- Geographic Information System
G/FLRPC---Genesee/Finger Lakes Regional Planning Council
GWDR---Ground Water Disinfection Rule
IO--- Intermunicipal Organization
IUP--- Intended Use Plan
IWI--- Index of Watershed Indicators
MCL--- Maximum Contaminant Level
MCLG---Maximum Contaminant Level Goal
MOSF---Major Oil Storage Facility
NCWS---Non-Community Water System
NEP--- National Estuary Program
NEPA---National Environmental Policy Act
NOAA---National Oceanic and Atmospheric Administration
NPDES---National Pollutant Discharge Elimination System
NPS--- Nonpoint Source
NRCS---Natural Resource Conservation Service
NYSDEC---New York State Department of Environmental Conservation
NYSDOS---New York State Department of State
NYSDOH---New York State Department of Health
NYSORPS---New York State Office of Real Property Services
OPRHP---Office of Parks, Recreation, and Historical Preservation
OSM--- Office of Surface Mining
PBS--- Petroleum Bulk Storage

PWL---Priority Waterbodies List
PWS--- Public Water System
RCRA---Resource Conservation and Recovery Act
RMP--- Resource Management Plan
SCS--- Soil Conservation Service
SDWA--Safe Drinking Water Act
SDWIS---Safe Drinking Water Information System
SEQR---State Environmental Quality Review Act
SMP--- State Management Plan
SPDES---State Pollution Discharge Elimination System
SSA--- Sole Source Aquifer
STORET---STOrage and RETrieval U.S. Waterways data system
STP--- Sewage Treatment Plant
SWAP---Source Water Assessment Program
SWCD---Soil and Water Conservation District
SWCP---State Wetlands Conservation Plan
SWP--- Source Water Protection
SWTR---Surface Water Treatment Rule
TMDL---Total Maximum Daily Load
TOT--- Time-of-Travel
TRI--- Toxic Release Inventory
UIC--- Underground Injection Control
USDA---United States Department of Agriculture
USEPA---United States Environmental Protection Agency
USGS---United States Geological Survey
UST--- Underground Storage Tank
UWA--- Unified Watershed Assessment
WHP--- Wellhead Protection Program
WHPA---Wellhead Protection Area
WQCC---Water Quality Coordinating Committee